(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 October 2004 (21.10.2004)

PCT

(10) International Publication Number
WO 2004/090335 A1

(51) International Patent Classification[7]: F04B 45/047, 43/04, F04F 7/00, F04B 43/00

(21) International Application Number: PCT/GB2004/001526

(22) International Filing Date: 7 April 2004 (07.04.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0308197.3 9 April 2003 (09.04.2003) GB

(71) Applicant *(for all designated States except US)*: **THE TECHNOLOGY PARTNERSHIP PLC** [GB/GB]; Melbourn Science Park, Melbourn, Royston, Hertfordshire SG8 6EE (GB).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **JANSE VAN RENSBURG, Richard, Wilhelm** [GB/GB]; 16 Colesfield, Longstanton, Cambridge CB4 5BW (GB). **SELBY, Robert, Gordon, Maurice** [GB/GB]; 6 Thatcher Stansford Close, Melbourn, Royston, Hertfordshire SG8 6EF (GB). **DUFOUR, Francoise, Florence** [FR/GB]; 64 The Fairway, Mill Hill, London NW7 3HP (GB). **BUCKLAND, Justin, Rorke** [GB/GB]; 25 Albert Street, Cambridge CB4 3BE (GB). **SOMERVILLE, John, Matthew** [GB/GB]; 28 Cambridge Crescent, Bassingbourn, Nr. Royston, Hertfordshire SG8 5LP (GB).

(74) Agent: **GILL JENNINGS & EVERY**; Broadgate House, 7 Eldon Street, London EC2M 7LH (GB).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

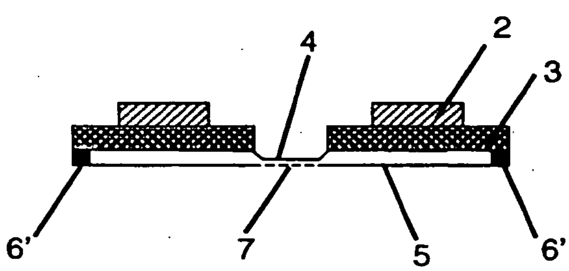
(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 2004/090335 A1

(54) Title: GAS FLOW GENERATOR



(57) Abstract: A gas flow generator comprising: an ultrasonic driver comprising a piezoelectric or electrostrictive transducer mounted on a substrate, operation of the transducer being arranged to cause the driver to bend; a first membrane disposed on or formed integrally with the transducer or the substrate; and a second membrane mounted substantially parallel with the driver and spaced a given distance therefrom, one of the membranes being perforate, whereby ultrasonic bending of the driver on actuation of the transducer causes a gas flow through the perforate membrane.

THIS PAGE IS BLANK
THIS PAGE IS BLANK

JC05 Rec'd PCT/PTO 03 OCT 2005

Ce\PRTS

GAS FLOW GENERATOR

10/551788

The present invention relates to a gas flow generator and, more particularly, to a gas flow generator incorporating a piezoelectric or electrostrictive device.

Modern electronic devices, particularly portable devices such as laptop computers, mobile telephone and the like are becoming ever more powerful, thus increasing the amounts of electrical power used by, in particular, microprocessors employed in such devices, and therefore there is a growing need for cooling of such microprocessors. Cooling is also required in electro-chemical batteries and other gas flow requirements are to be found in, for example, fuel cells.

Various types of cooling are known, for example using fans, heat pipes or Peltier devices, but these suffer from a number of problems such as expense, noise, power consumed or size, for example. It has been proposed, see US-4753579-A, to utilise a piezoelectric transducer to cause movement of a blade, which may be tapered and which may carry a hinged perforated membrane, acting as an amplifier to cause a flow of gas around the blade.

It is also known, see US-5914856-A, to utilise a piezoelectric driver in conjunction with a one way valve to cause a flow of gas. However, the requirement to provide highly miniaturised valves is problematic since they are both expensive and prone to failure.

The present invention is aimed at providing a sufficiently strong and efficient gas flow from a thin-walled device capable of being provided with a low profile and having light weight which additionally does not require the use of separate valves.

According to the present invention, there is provided a gas flow generator comprising:

an ultrasonic driver comprising a piezoelectric or electrostrictive transducer mounted on a substrate, operation of the transducer being arranged to cause the driver to bend;

a first membrane disposed on or formed integrally with the transducer or the substrate; and

a second membrane mounted substantially parallel with the driver and spaced a given distance therefrom,

one of the membranes being perforate, whereby ultrasonic bending of the driver on actuation of the transducer causes a gas flow through the perforate membrane.

The perforate membrane may be either or both of the first or second membranes.

The second membrane may be disposed on or formed integrally with a second ultrasonic driver. In this manner, the second driver will mirror the first driver in a plane through the first and second membranes.

Preferably, the ultrasonic drivers are piezoelectric transducers having a thickness substantially the same as the substrate to which it is mounted and preferably the substrate and the piezoelectric transducer have substantially comparable stiffness which, when the transducer is caused to expand (substantially in the plane of the driver) causes the driver to bend, carrying the first membrane with it. WO-93/10910-A discloses a piezoelectric actuator of a similar type employed for the generation of fluid droplets.

The driver may be operated at mechanical resonance to produce large amplitude vibrations in the bending mode. An annular ultrasonic driver may be used, in which case the substrate may include, either integral or mounted thereon, a non-perforate membrane, effectively closing the central aperture in the driver, with gas flow through the opposing perforate membrane spaced from the substrate, or the perforate membrane may be integral with or mounted on the substrate with the non-perforate membrane being opposed. A further embodiment may include two perforate membranes, one on the substrate and one opposing it, gas flow being through both.

The perforate membrane may then be supported on the substrate of the driver by a spacer, for example, a generally annular spacer and an opening can be provided through the spacer to allow gas flow into a cavity formed between the driver and the perforate membrane. In use, the volume of the cavity alternately expands and contracts creating a differential pressure and hence a gas flow through the device.

In an alternative construction, the first membrane is perforate and gas flow is through the aperture in the annular driver.

The second membrane may be mounted, preferably via a spacer, on an annulus which itself is connected to the driver by means of a plurality of spokes, wherein the annulus surrounds the outer portion of the driver.

One or each of the membranes may have an irregular shape and, preferably, this shape includes a plurality of channels which may extend substantially towards the centre of the membrane, so as to increase the effective outer perimeter of the membrane. It is preferable for at least some of the perforations to be arranged around

the perimeter of the membrane, preferably at a substantially similar distance from the edge.

The gas flow generator according to the present invention may also be provided with one or more heat sinks and these may be either single or double sided. The heat sinks are arranged so as to be in the line of gas flow away from the perforate membrane.

The gas flow can be used to cool microelectronic and other devices as mentioned above or to supply gas flow for other purposes though devices requiring a gas flow therethrough.

Examples of gas flow generators constructed in accordance with the present invention will now be described with reference to the accompanying drawings in which:

Figs. 1 and 2 are cross-sections through thin-walled ultrasonic drivers which may be used in a generator of the present invention;

Figs. 3 and 4 illustrate plan views of the same drivers;

Figs. 5 and 6 illustrate two further drivers, in plan view, but rectangular in outline, rather than circular as in Figs. 3 and 4, but having substantially the same cross-section (see therefore Figs. 1 and 2);

Figs. 7 and 8 illustrate the bending modes of the drivers of Figures 1 and 2 respectively;

Figs. 9, 10 and 11 illustrate examples of generators according to the present invention in cross-section;

Fig. 12 is a plan view of the generator shown in cross-section in Fig. 11;

Figs. 13 and 14 are graphs showing typical membrane separation during actuation of the driver and corresponding pressures developed within the cavity between the membranes, respectively;

Figs. 15a to 15c show different possible cross-sections for the perforations in a perforate membrane;

Figs. 16 to 18 show different arrangements of perforations in the perforate membrane;

Figs. 17a and 17b show side and plan views respectively of the membrane shown in Fig. 17;

Fig. 19a illustrates the flow of gas through a device operating in a pump mode;

Fig. 19b illustrates the gas flow when the present invention is operating in a jet mode;

Figs. 20a and 20b show schematic cross sectional views through a device according to the present invention when used with a single and a double heat sink, respectively; and

Figs. 21a and 21b)show perspective views of a single and a double heat sink, respectively.

Figures 1 and 3 illustrate a first ultrasonic driver 1, in the form of a disc 2 of a piezoelectric material (e.g. PZT) bonded to a larger diameter disc of stainless steel 3 on one side, on the other side of the stainless steel 3 disc being bonded a circular stainless steel membrane 4. An active ultrasonic driver is formed by connecting electrodes on opposite sides of the piezoelectric disc 2 (which are not shown - for purposes of clarity) so that when an electric field is applied across the piezoelectric disc 2 and it responds by attempting to change shape. As long as the substrate 3 and the piezoelectric material 2 are of comparable stiffness, the driver is caused to bend and, when operated at mechanical resonance, large vibration amplitudes can be created in the substrate. In turn therefore the stainless steel membrane 4 is also caused to flex.

A similar driver is shown in Figures 2 and 4 and the same reference numerals are used for simplicity, but in this case the piezoelectric disc 2 and the substrate 3 are annular. The stainless membrane is circular and effectively closes the aperture in the centre of the substrate 3.

Corresponding linearly-acting rectangular drivers 11 are shown in Figs. 5 and 6 with the same numbers being used for similar components for ease of reference.

The bending modes of the drivers shown in Figs. 1, 3 and 5 and 2, 4 and 6 respectively and used in the generality of Figs. 9 to 11, are shown in Figs. 7 and 8.

The driver shown in Fig. 2 is incorporated in a gas flow generating device as shown in Figs. 9, 10 and 11. In the device shown in Fig. 10, a second stainless membrane 5 is shown spaced at a suitable distance, typically up to 10mm, from the membrane 4 and is held in position by an annular spacer 6, thereby forming a cavity 10 between the membrane 5 and the driver 1. However, a flow maxima is generally seen when the separation between the membranes is small, typically less than 200 μm, but as the separation is increased a series of additional maxima are seen. These are thought to be due to resonant behaviour in the cavity. The centre part of the stainless membrane 5 is provided with perforations 7 therethrough which may be in the form of tapered or non-tapered orifices. Some examples of orifice shapes are shown in Figs. 15a to 15c. The tapered orifices may be forward tapered, i.e. narrowing in the direction

of flow as shown in Figure 15a or reverse-tapered, i.e. narrowing in the opposite direction as shown in Fig 15b to the flow.

In the example generator shown in Fig. 9, the membrane 4 is deformed at its centre to form a domed portion, and is accordingly closely spaced from the membrane 5. The remainder of the membrane 5 is held at a greater distance from the remainder of the driver 1 by a spacer 6', thus providing the cavity 10 between the membranes with a larger volume than the corresponding cavity in Figs. 9 or 11.

The example generator shown in Fig. 11 is broadly similar to that of Fig. 9, but avoids any direct coupling between the membrane 5 and the driver 1 by supporting the membrane 5 via the spacer 6" on an annulus 8 which is connected to the substrate 3 of the driver 1 by a plurality of spokes 9 (see Fig. 12).

The generator of the present invention may operate in one of several different modes, although it is not, at this stage, apparent exactly what conditions on the device and the gas which is to be moved ensures that any particular mode is the one in which the generator operates.

In operation of all of the devices shown above, the membrane 4 attached to the driver is caused to vibrate so that the cavity between the membranes 4,5 alternately expands and contracts. The device can operate such that sinusoidal movement between the two membranes compresses and rarifies the air. Asymmetry, resulting either from the size, shape or direction of tapering of the holes or in the position of the driver, enables a differential pressure to be generated within the cavity as shown in Fig. 14 so that a DC gas flow is caused from the inside and the outside of the cavity 10. In the device shown in Fig. 11, gas flow may be through the gap from the annulus 8 and the substrate 3, into the cavity 10 and then through the perforations in the membrane 5, but in other constructions gas flow may be through apertures (not shown) formed in the membrane 4 or in the spacers 6, 6'.

Alternatively, the generator can act as a compression pump with an inlet, e.g. the gap between the two membranes 4, 5, and an outlet, e.g. the holes in perforate membrane 5. When the piezoelectric disc 2 is driven, the pressure behind the holes varies harmonically with the separation of the two membranes. The two membranes moving relative to each other causes partial valving such that when the membranes are close together, the valve is "closed" and when they are their furthest separation, the valve is "open". When the pressure behind the holes is at a maximum, the resistance of the gap between the plate is also at a maximum. When the pressure behind the

holes is at a minimum, the resistance with the gap between the plates is also at a minimum. This results in a net flow of gas from the inlet to the outlet.

In this operation, the flow rate is typically limited by the viscous drag of the gas through the gap between the membranes 4, 5 and there is an optimum restriction between the plates for a given hole size in the perforate membrane 5. When the separation between the driver and the membrane is small, this optimum occurs when the average resistance of the gap between the two membranes and the resistance through the holes is equal. However, this also means that there is an optimum position of the perforations in the membrane 5. Fig. 16 illustrates the location of this optimum hole position, relative to the outer edge 20 of the domed portion of the membrane 4. In Fig. 16, only a single ring of holes 21 through perforate membrane 5 can be in the optimum position, namely a set distance from the inlet ie the edge 20 of the domed portion of the driven membrane area. To improve this, the membrane can be shaped as shown in Figure 17 in which channels 22 are formed in the perforate membrane 5, so as to increase the effective perimeter of the membrane. This results in the number of perforations in the optimum location 21 increasing, as a result of the larger effective perimeter. Alternatively, and as shown in Figure 18, inlet holes 23 (typically larger than the perforations) can be provided in the membrane 4, midway between the centre and the edge of the domed portion of membrane 4 and, as such, a further inner ring of optimum hole positions 24 is created in the perforate membrane 5. Figs. 17a and 17b show a version of the membrane 5 of Fig. 17, in which 8 channels 22 are provided and in which the perforate portion is domed.

As mentioned above, the holes through the perforate membrane 5 may be tapered as shown in Figs. 15a and b and, as this creates an asymmetric sinusoidal pressure variation as the membranes are moved relative to each other, the tapers on the holes create a net DC flow. The taper on the orifice acts as a passive valve. Fig. 15c illustrates a non-tapered orifice.

In the arrangement shown in Fig. 19a, the gas flow generator 1, similar to that in Fig.10, operates so as to produce a pump flow through the perforate membrane 5, drawing gas in to the cavity 10 from its edge. In contrast, in Fig. 19b, air oscillates through the perforations in membrane 5. On the compressive stroke, a highly directional inertial jet is generated from the perforations, whilst on the opposing stroke, a more isotropic flow is created through the perforations into the cavity 10. This causes a strong jet flow perpendicular to the surface of the membrane.

Any of the devices previously described can be used, in conjunction with a heat sink to help dissipate heat from electrical components. Such arrangements are shown in Figs. 20a and 20b in which a gas flow generator substantially similar to the arrangement shown in Fig. 9 is spaced a short distance from the upper surface of a respective single or double heat sink. In Fig. 20a a single heat sink is mounted adjacent the perforate membrane 5 such that the pumped flow from the perforate membrane 5 flows from the centre, radially outward in the plurality of channels 34 (see Fig. 21a). In the arrangement in Fig. 20b, a double sided heat sink 33 is provided and this is of particular use when the gas flow generator is operating in the jet mode, as per Fig. 19b, as the gas which is drawn along the face of the perforate membrane 5 is also cause to flow along the upper side of the heat sink in channels 35. The jet flow from perforate membrane 5 passes through the centre of the heat sink. The jet flow then passes through channels 36 on the underside of the heat sink 33 (see Fig. 21b).

The separation between the two membranes 4, 5 may be from 0.01 mm to 10 mm, but preferably is no more than 1 mm and is preferably less than 200μm. The size of the perforations through the membrane 5 is preferably in the range of 5 to 150 microns diameter and are typically spaced at a 500 micron hexagonal pitch. The preferred hole size is, however, between 25 and 125 microns. In testing, the gas flow generator of the present invention has been shown to cool a 1 watt load by 17°C, i.e. for 87°C without the present invention to 70°C with the present invention, when the generator and the heat load are separated by 2 mm. This is when the device is operating to generate a jet from the surface of the device.

The particular direction of the gas flow will be determined to the particular use by which the gas flow generator is put in practise.

In examples tested to date, perforations with a hole size of 50 to 150μm at a pitch of 350 to 800μm have been utilised, together with a driver operating with a 5μm amplitude. Operation with smaller diameter holes and correspondingly smaller diameter pitch between the holes and smaller separation between the membranes will create lower flow rates but at higher pressures. For example 7 micron diameter holes on 60 micron pitch were found to create pressures up to 10kPa.

Although stainless steel has been used for the membranes shown in the examples, other materials such as Kapton and brass may be utilised where desirable or acceptable.

CLAIMS

1. A gas flow generator comprising:

an ultrasonic driver comprising a piezoelectric or electrostrictive transducer mounted on a substrate, operation of the transducer being arranged to cause the driver to bend;

a first membrane disposed on or formed integrally with the transducer or the substrate; and

a second membrane mounted substantially parallel with the driver and spaced a given distance therefrom,

one of the membranes being perforate, whereby ultrasonic bending of the driver on actuation of the transducer causes a gas flow through the perforate membrane.

2. A gas flow generator according to claim 1, wherein either or both of the first or second membranes is perforate.

3. A gas flow generator according to claim 1, wherein the second membrane is disposed on or formed integrally with a second ultrasonic driver.

4. A gas flow generator according to one of claims 1 to 3, wherein one or each of the ultrasonic drivers is a piezoelectric transducer.

5. A gas flow generator according to claim 4, wherein the substrate and the piezoelectric transducer have substantially comparable stiffness.

6. A gas flow generator according to any one of the preceding claims, wherein the ultrasonic driver is annular.

7. A gas flow generator according to any one of the preceding claims, wherein the second membrane is supported on the substrate of the driver by a spacer.

8. A gas flow generator according to claim 7, wherein the spacer is generally annular and has an opening through which gas can flow into and out of a cavity formed between the driver and the second membrane.

9. A gas flow generator according to claim 7 or claim 8, wherein the spacer is mounted on an annulus which is connected to the ultrasonic driver by means of a plurality of spokes.

10. A gas flow generator according to any one of the preceding claims, wherein one or both of the first and second membranes is provided with one or more channels.

11. A gas flow generator according to any one of claims 1 to 5, wherein the ultrasonic driver is linear.

10/551788

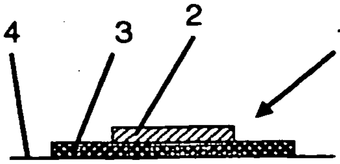


Fig. 1

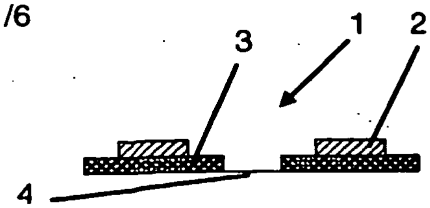


Fig. 2

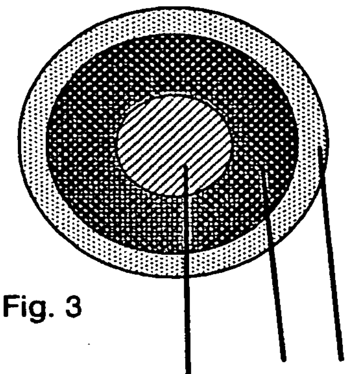


Fig. 3

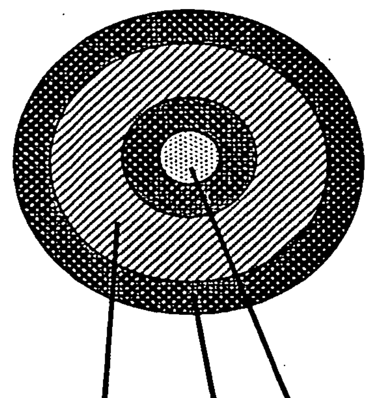


Fig. 4

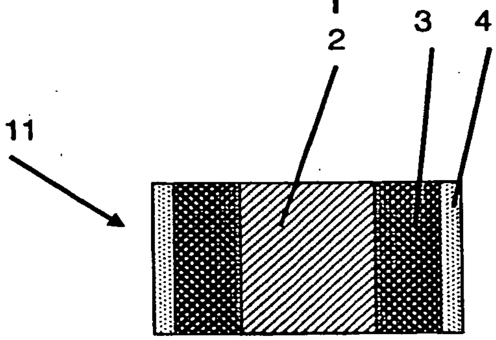


Fig. 5

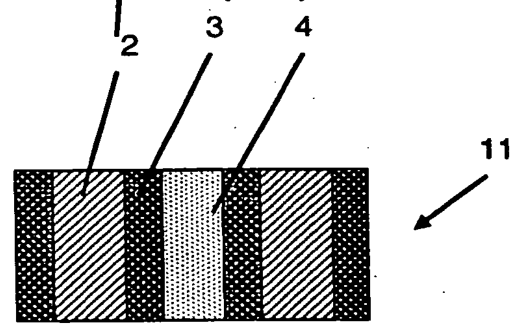


Fig. 6

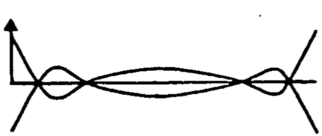


Fig. 7

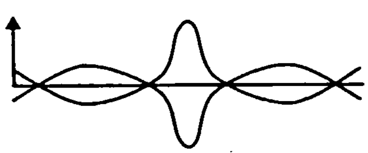


Fig. 8

Fig. 9

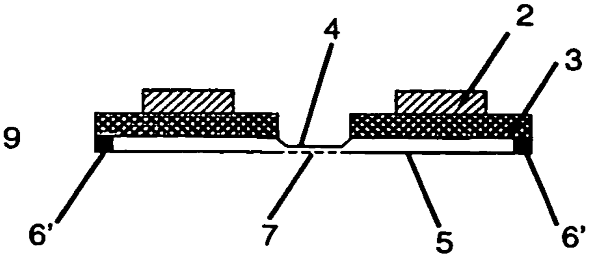


Fig. 10

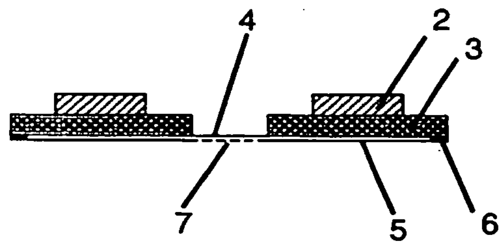
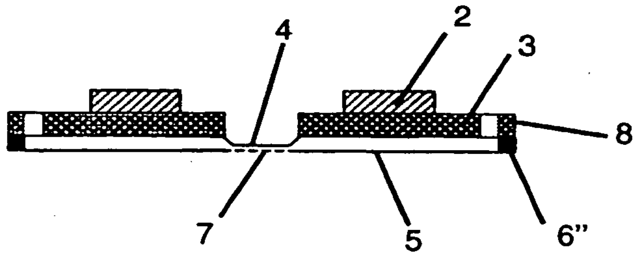


Fig. 11



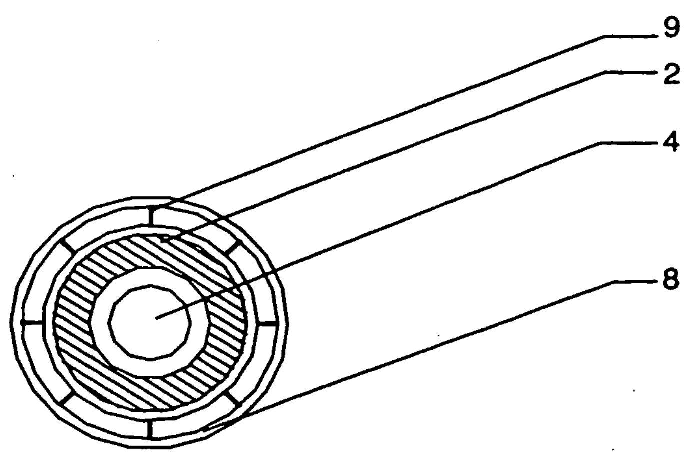


Fig. 12

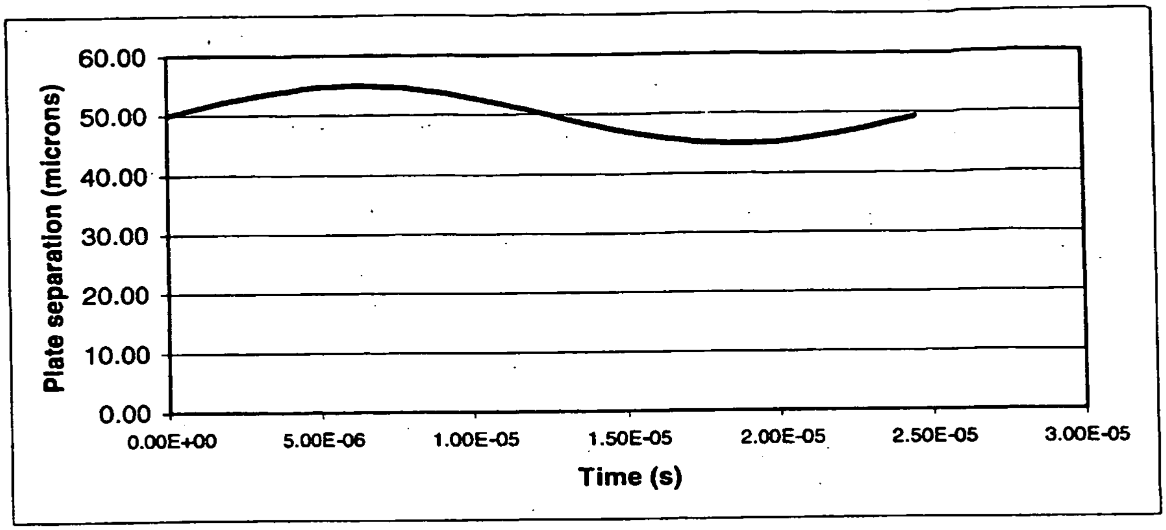

60.00
50.00
40.00
30.00
20.00
10.00
0.00
Plate separation (microns)
0.00E+00
5.00E-06
1.00E-05
1.50E-05
2.00E-05
2.50E-05
3.00E-05
Time (s)

Fig. 13

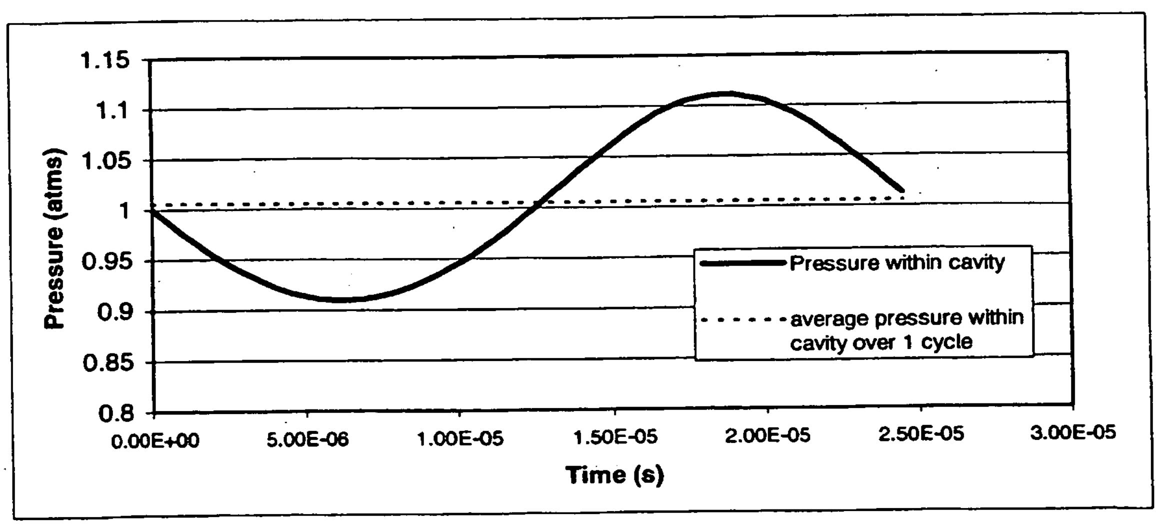

1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
Pressure (atms)
Pressure within cavity
average pressure within cavity over 1 cycle
0.00E+00
5.00E-06
1.00E-05
1.50E-05
2.00E-05
2.50E-05
3.00E-05
Time (s)

Fig. 14

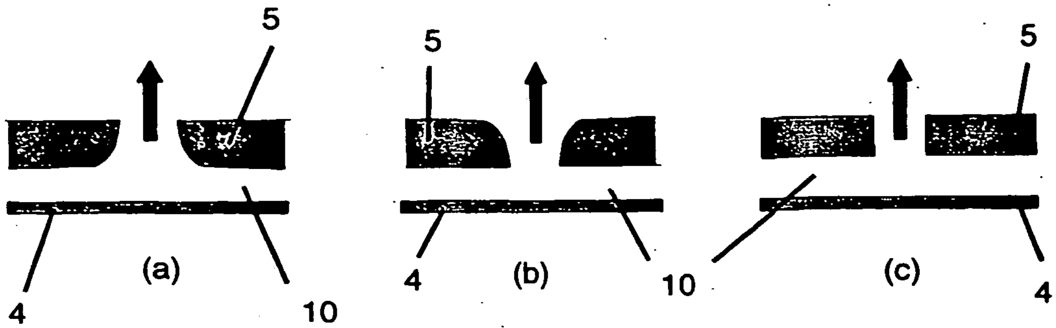
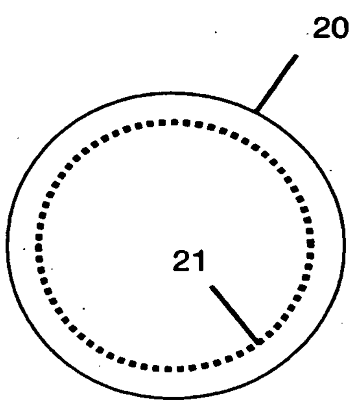
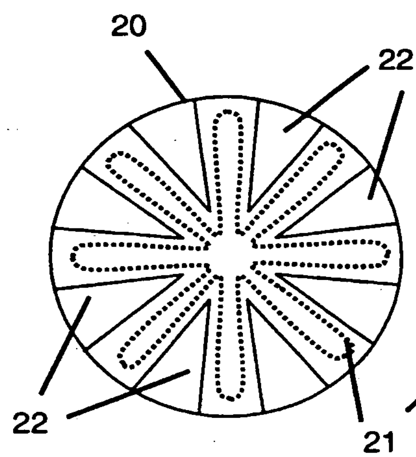


Fig.15





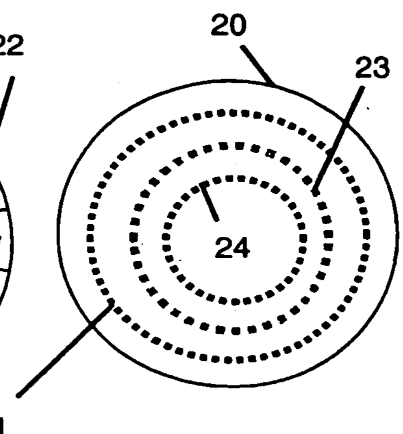


Fig.16

Fig.17

Fig.18

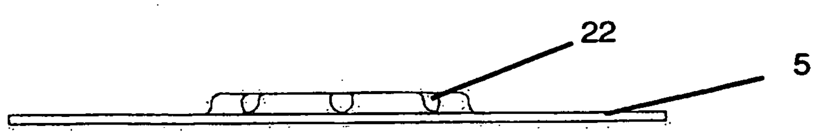


Fig.17a

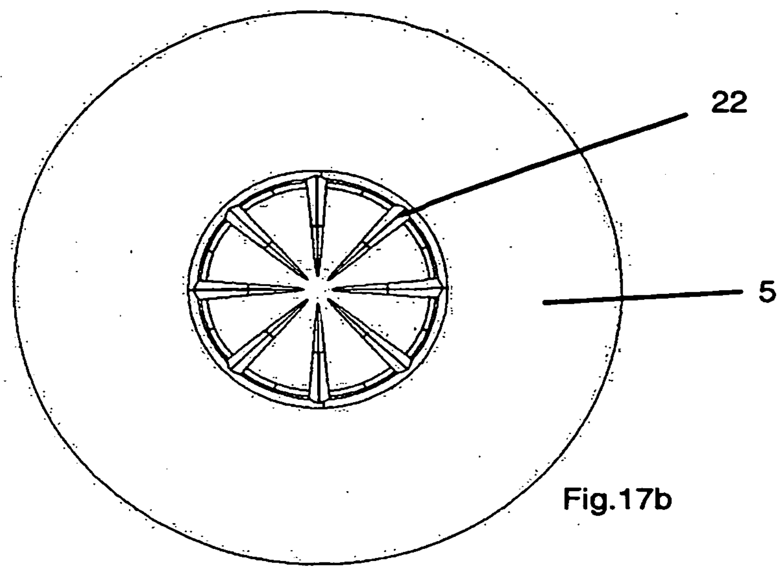


Fig.17b

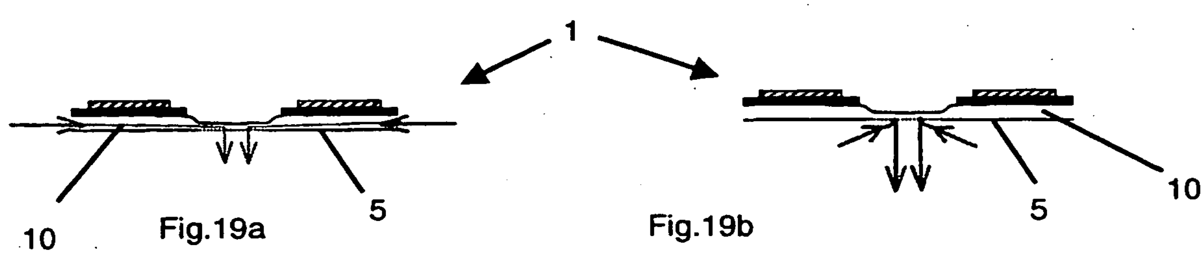


Fig.19a

Fig.19b

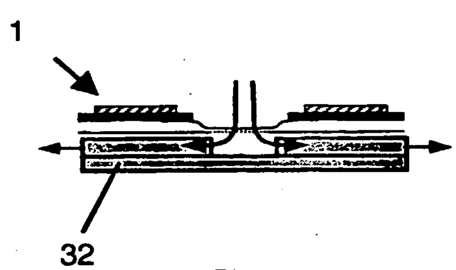


Fig.20a

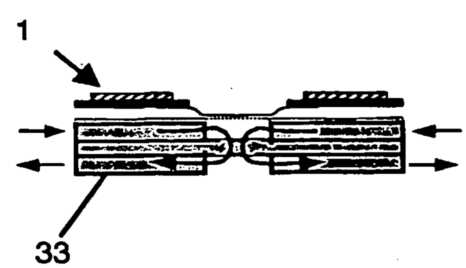


Fig.20b

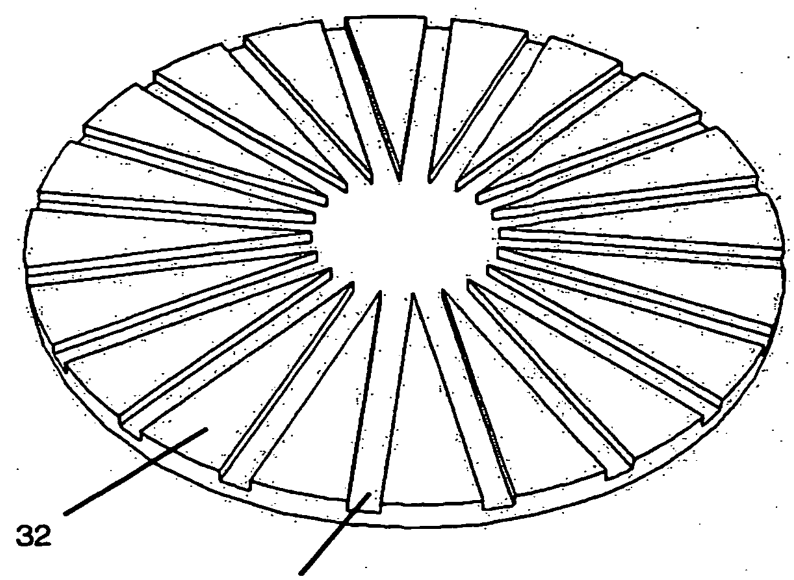


Fig.21a

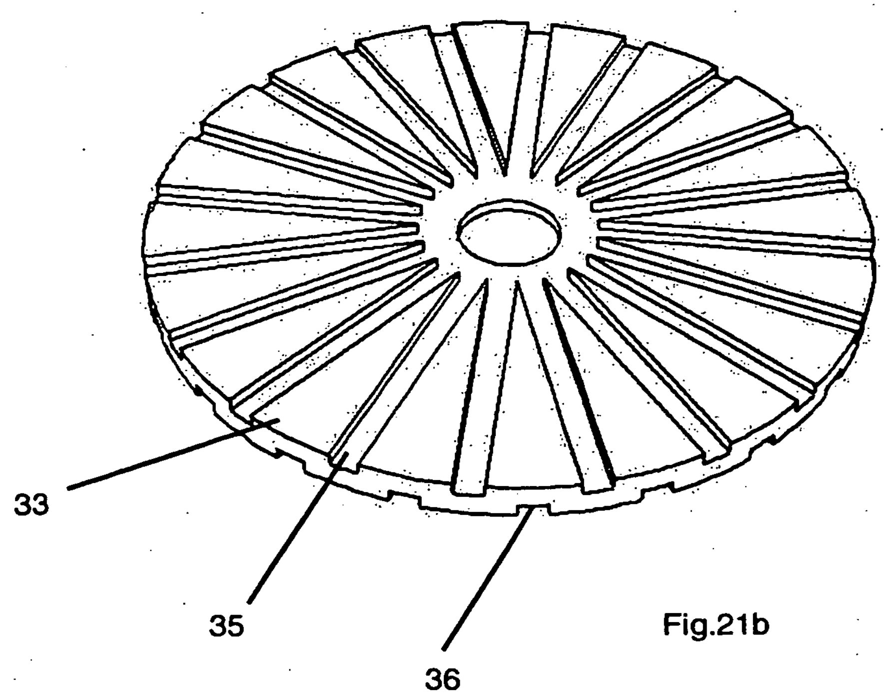


Fig.21b

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB2004/001526

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F04B45/047 F04B43/04 F04F7/00 F04B43/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F04B F04F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 525 041 A (DEAK DAVID) 11 June 1996 (1996-06-11) abstract column 9, line 30 - column 10, line 45 column 12, line 33 - column 13, line 11 figures 1,5 -----	1,4
A	US 6 164 933 A (MASAKI YASUFUMI ET AL) 26 December 2000 (2000-12-26) abstract column 4, line 34 - line 57 column 8, line 66 - column 9, line 5 figures 4,18,19 -----	1,3,4

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 July 2004	09/07/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Kolby, L

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB2004/001526

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 93/10910 A (TECHNOLOGY PARTNERSHIP) 10 June 1993 (1993-06-10) cited in the application abstract page 13, line 7 - page 15, line 13 figures 1-5	1,2,4,6
A	DE 44 22 743 A (GERLACH TORSTEN) 4 January 1996 (1996-01-04) abstract column 2, line 60 - column 4, line 26 column 4, line 63 - column 5, line 6 figures 1-3,7	1,2,4

INTERNATIONAL SEARCH REPORT

In ional Application No
Fc1/GB2004/001526

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 5525041	A	11-06-1996	US	5982801	A	09-11-1999
US 6164933	A	26-12-2000	JP	11311184	A	09-11-1999
			JP	2000171320	A	23-06-2000
			DE	19918694	A1	04-11-1999
			DE	29924151	U1	11-04-2002
WO 9310910	A	10-06-1993	AT	131421	T	15-12-1995
			AU	665222	B2	21-12-1995
			AU	3090292	A	28-06-1993
			DE	69206824	D1	25-01-1996
			DE	69206824	T2	23-05-1996
			EP	0615470	A1	21-09-1994
			WO	9310910	A1	10-06-1993
			JP	2849647	B2	20-01-1999
			JP	7501481	T	16-02-1995
			US	5518179	A	21-05-1996
DE 4422743	A	04-01-1996	DE	4422743	A1	04-01-1996
			WO	9600849	A1	11-01-1996